REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
	Interim Research Performance Report (Monthly)	May 1 - May 31, 2013

4. TITLE AND SUBTITLE
Expeditionary Light Armor Seeding Development

5a. CONTRACT NUMBER

5b. GRANT NUMBER
N00014-13-1-0219

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Shridhar Yarlagadda, Bazle Haque

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
UNIVERSITY OF DELAWARE
OFFICE OF THE VICE PROVOST FOR RESEARCH
220 HULLIHEN HALL
NEWARK, DE 19716-0099

8. PERFORMING ORGANIZATION REPORT NUMBER
MONTHLY-2

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Office of Naval Research
875 North Randolph Street
Arlington, VA 22203-1995

10. SPONSOR/MONITOR'S ACRONYM(S)
ONR

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for Public Release; distribution is Unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

2D AutoDyn analyses of cylinder impact on ceramic plate have been conducted to identify the mesh size needed to capture detail crack growth in ceramic tiles
Steel 4340 is used for the projectile and AutoDyn SiC material properties are used for the ceramic tile
Mesh sensitivity analysis is performed using four different square mesh sizes:
- 0.50-mm x 0.50-mm square mesh
- 0.40-mm x 0.40-mm square mesh
- 0.30-mm x 0.30-mm square mesh
- 0.20-mm x 0.20-mm square mesh

Results shows that 0.20-mm mesh size provides a fracture pattern that may be considered acceptable for analysis
A conico-cylinder projectile is also used to study the fracture behavior with 0.20-mm mesh size
We will develop 3D FEMs for further AutoDyn analyses
An undergraduate student is working in the Summer 2013 session, and we are planning to recruit a graduate student in the Fall

15. SUBJECT TERMS
2D AutoDyn modeling, cylinder impact, conico-cylinder impact, fracture pattern, mesh sensitivity

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
UU					Shridhar Yarlagadda
a. REPORT	b. ABSTRACT	c. THIS PAGE	UU	15	19b. TELEPHONE NUMBER *(include area code)* 302-831-4941

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39.18

201306 14019

MONTHLY REPORT

MAY 2013

MODELING AND SIMULATION OF CERAMIC ARRAYS TO IMPROVE BALLAISTIC PERFORMANCE

Monthly Report for May 2013

ABSTRACT

- 2D AutoDyn analyses of cylinder impact on ceramic plate have been conducted to identify the mesh size needed to capture detail crack growth in ceramic tiles
- Steel 4340 is used for the projectile and AutoDyn SiC material properties are used for the ceramic tile
- Mesh sensitivity analysis is performed using four different square mesh sizes:
  - 0.50-mm x 0.50-mm square mesh
  - 0.40-mm x 0.40-mm square mesh
  - 0.30-mm x 0.30-mm square mesh
  - 0.20-mm x 0.20-mm square mesh
- Results shows that 0.20-mm mesh size provides a fracture pattern that may be considered acceptable for analysis
- A conico-cylinder projectile is also used to study the fracture behavior with 0.20-mm mesh size
- We will develop 3D FEMs for further AutoDyn analyses
- An undergraduate student is working in the Summer 2013 session, and we are planning to recruit a graduate student in the Fall 2013 session

SUBJECT TERMS

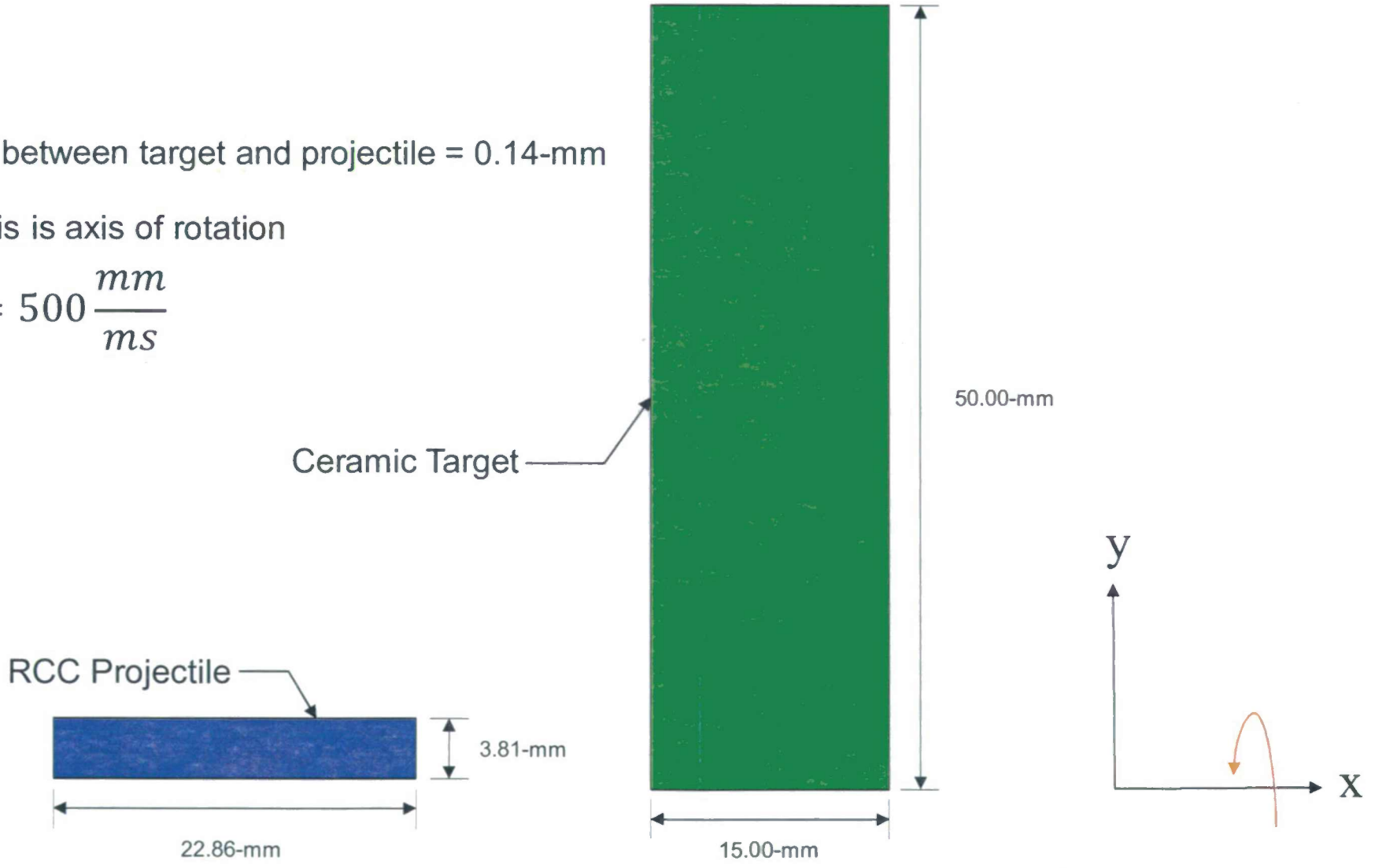
- 2D AutoDyn modeling, cylinder impact, conico-cylinder impact, fracture pattern, mesh sensitivity

Axi-Symmetric Model Geometry

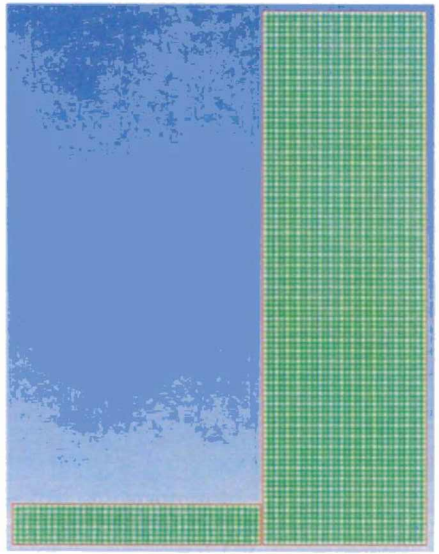
Gap between target and projectile = 0.14-mm

X-axis is axis of rotation

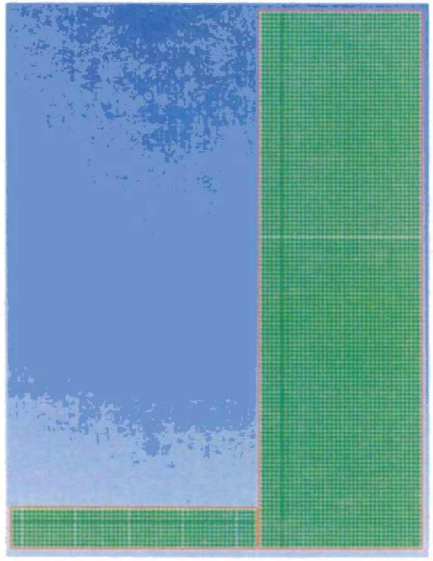
$$V_P = 500 \frac{mm}{ms}$$



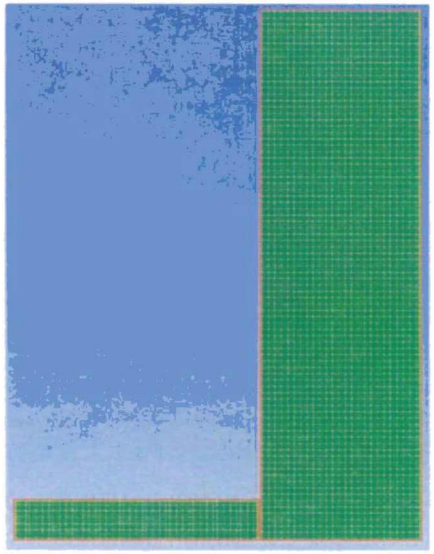
Different Mesh Sizes Investigated



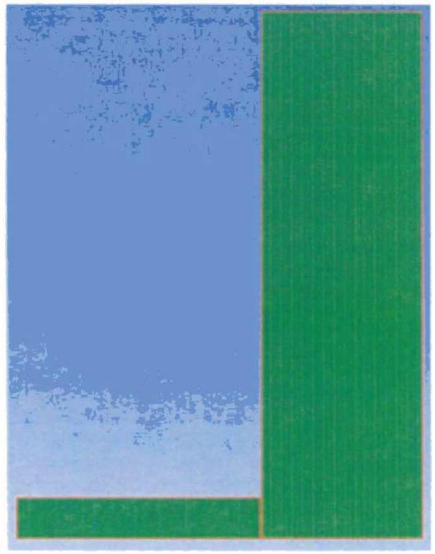
0.50-mm



0.40-mm

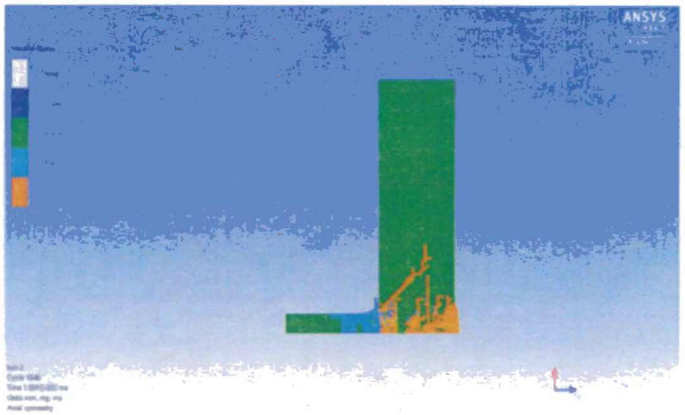


0.30-mm

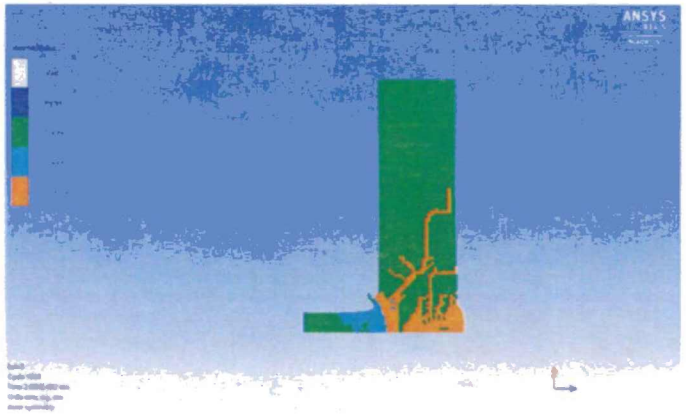


0.20-mm

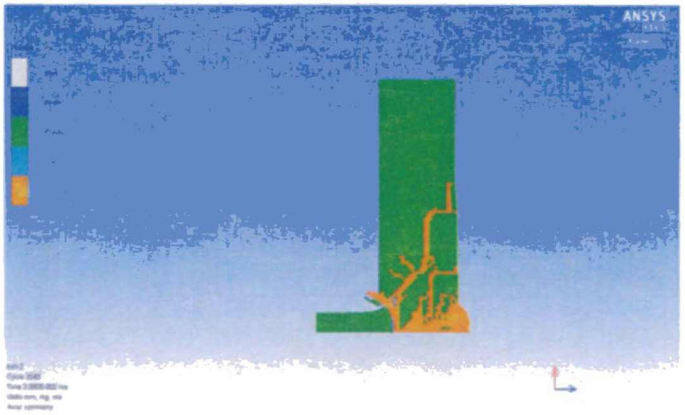
Fracture Pattern for 0.50-mm Mesh



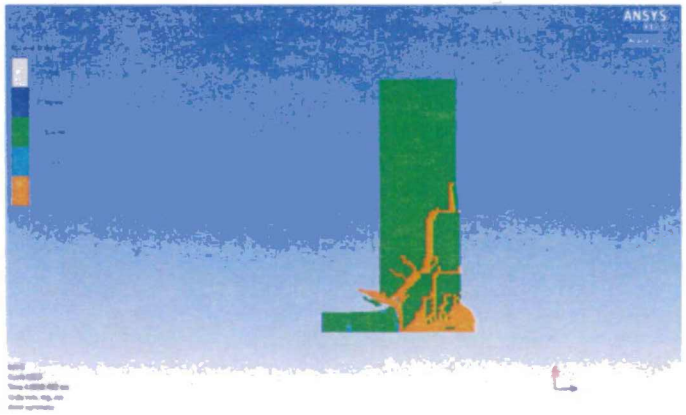
0.010-ms



0.020-ms

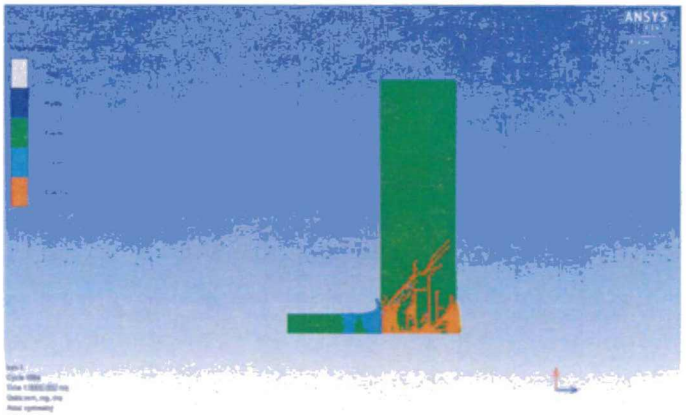


0.030-ms

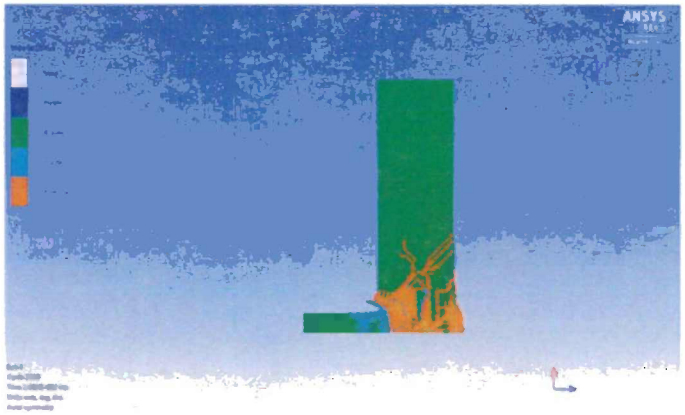


0.040-ms

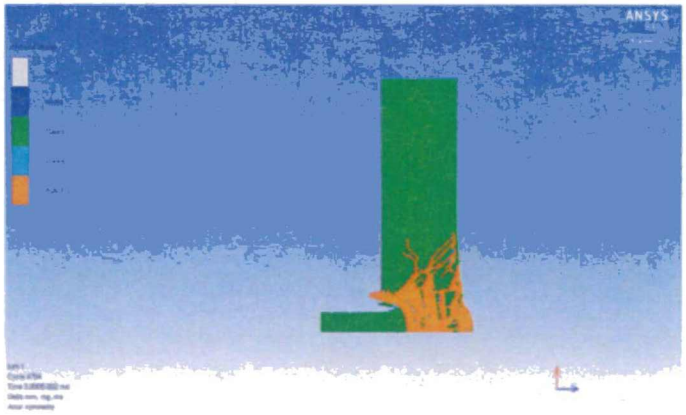
Fracture Pattern for 0.40-mm Mesh



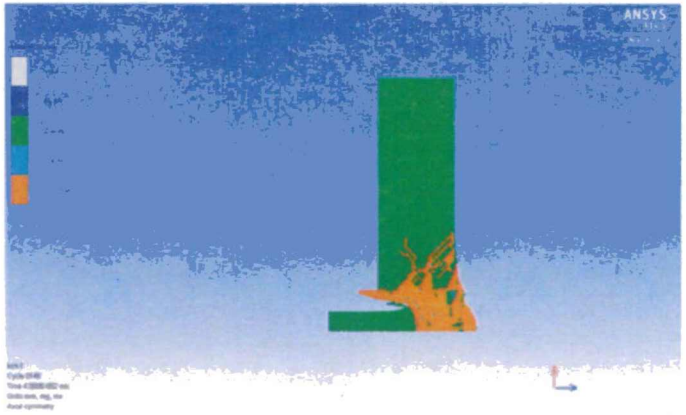
0.010-ms



0.020-ms

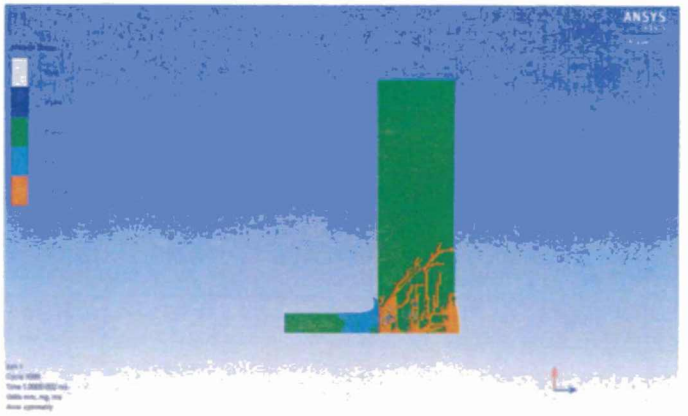


0.030-ms

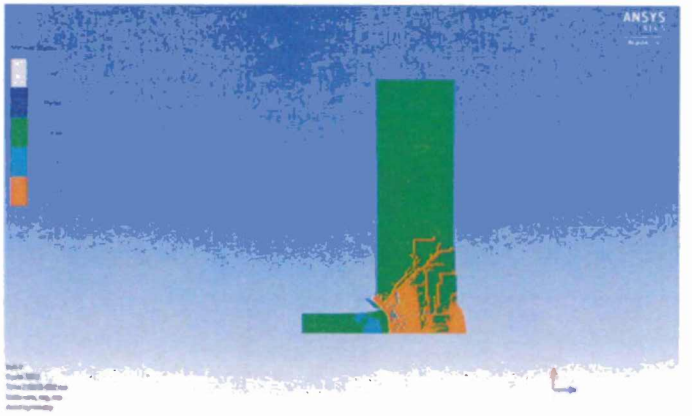


0.040-ms

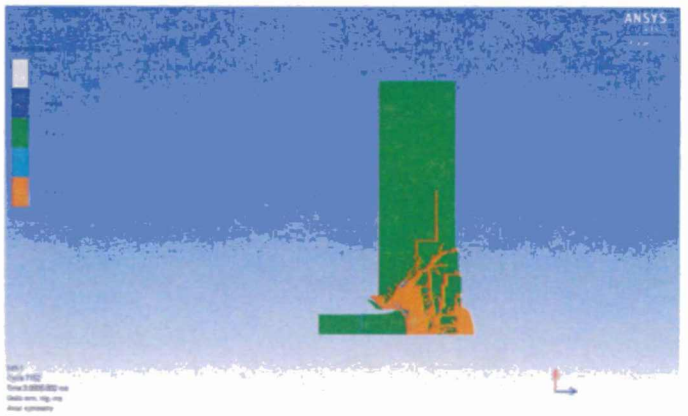
Fracture Pattern for 0.30-mm Mesh



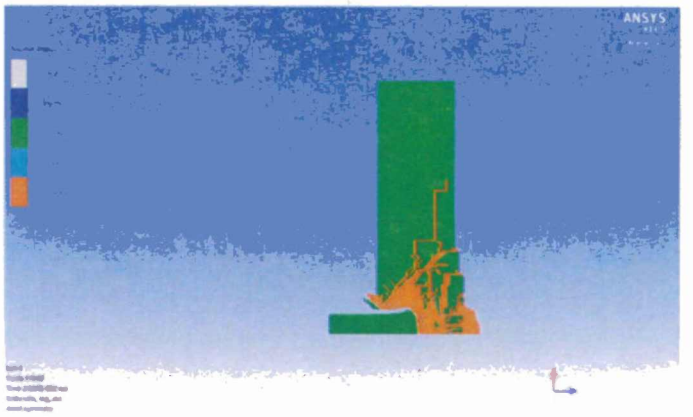
0.010-ms



0.020-ms

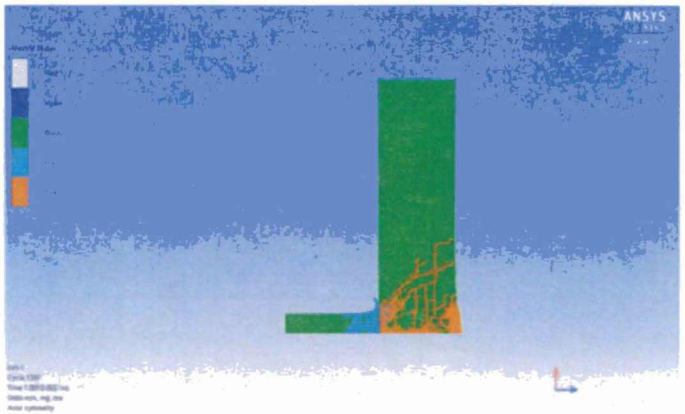


0.030-ms

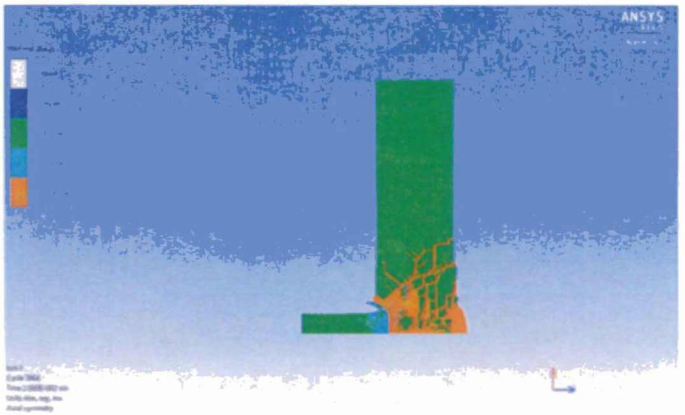


0.040-ms

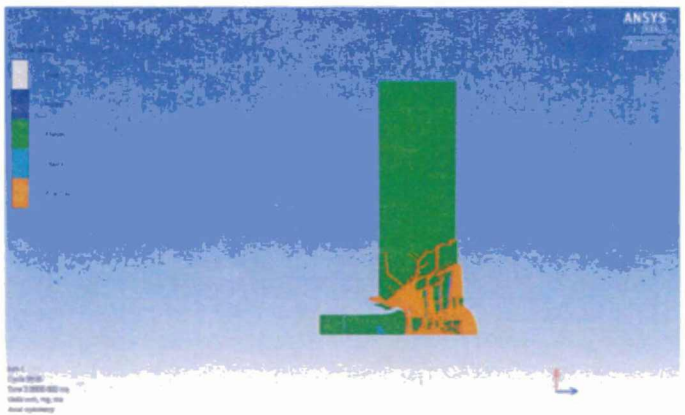
Fracture Pattern for 0.20-mm Mesh



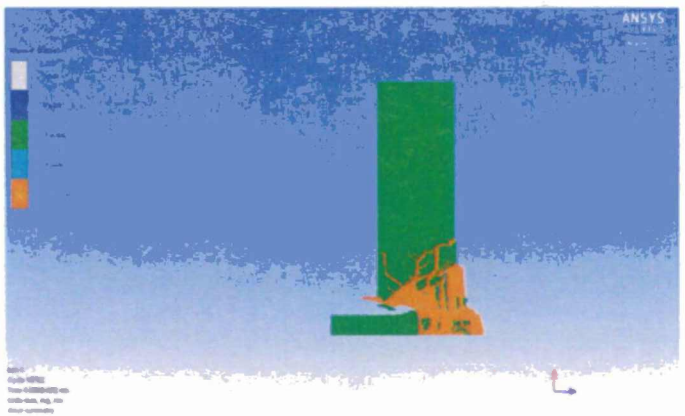
0.010-ms



0.020-ms

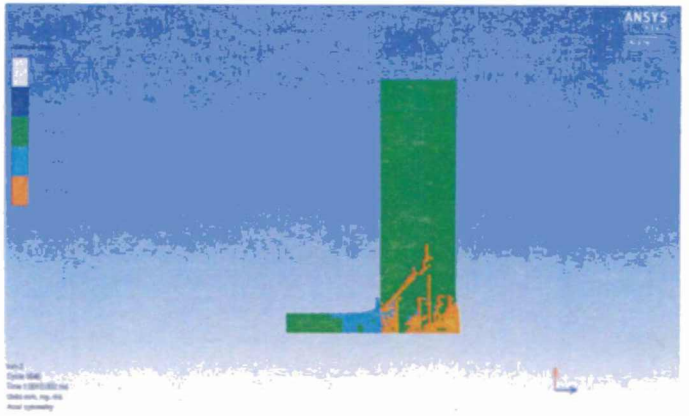


0.030-ms

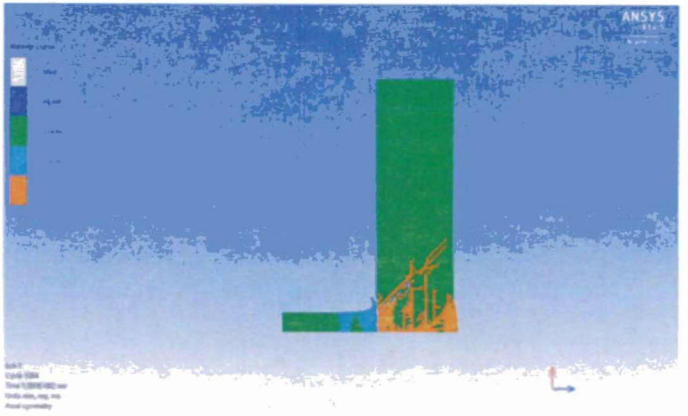


0.040-ms

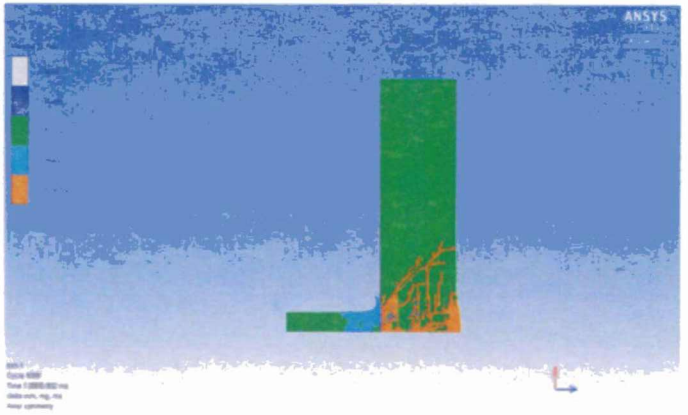
Fracture Patterns for All Mesh Sizes
t = 0.010-ms



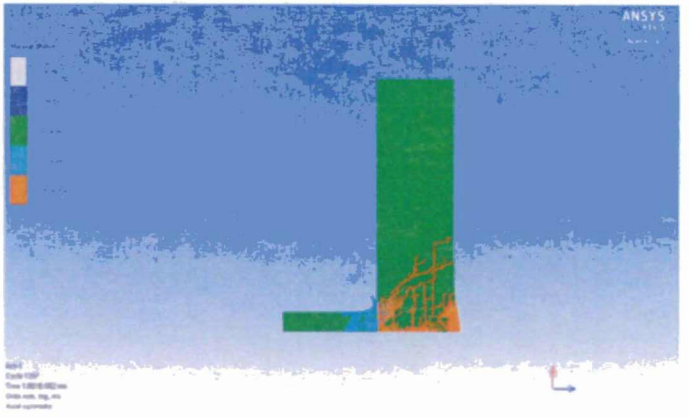
0.50-mm



0.40-mm

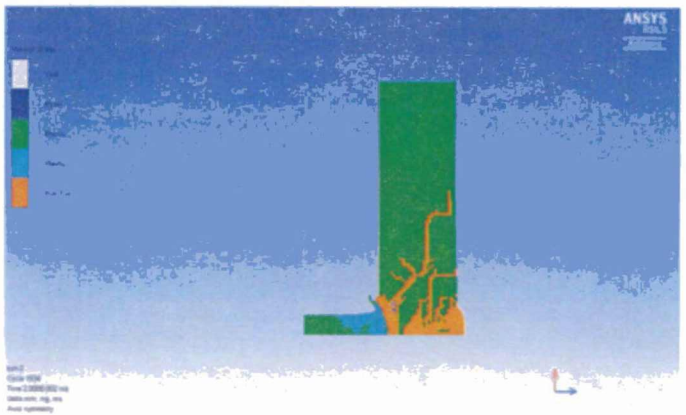


0.30-mm

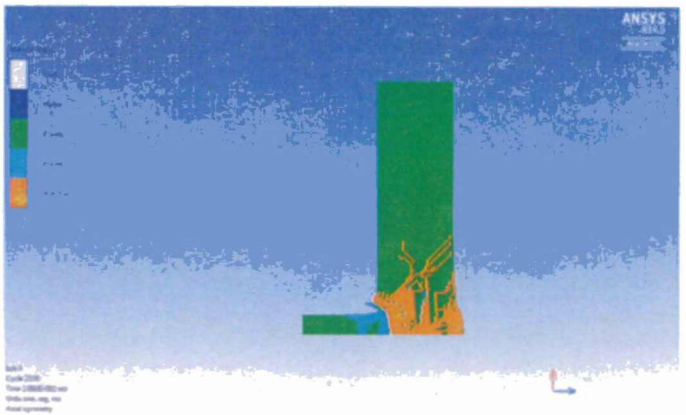


0.20-mm

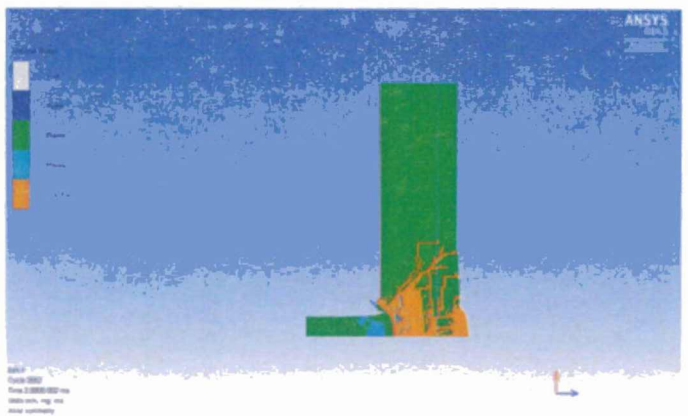
Fracture Patterns for All Mesh Sizes
t = 0.020-ms



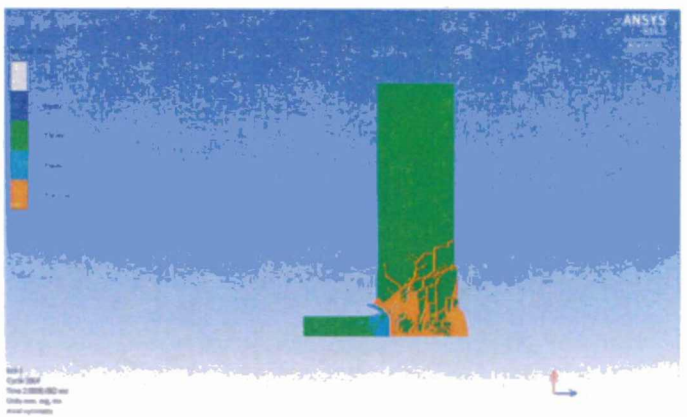
0.50-mm



0.40-mm

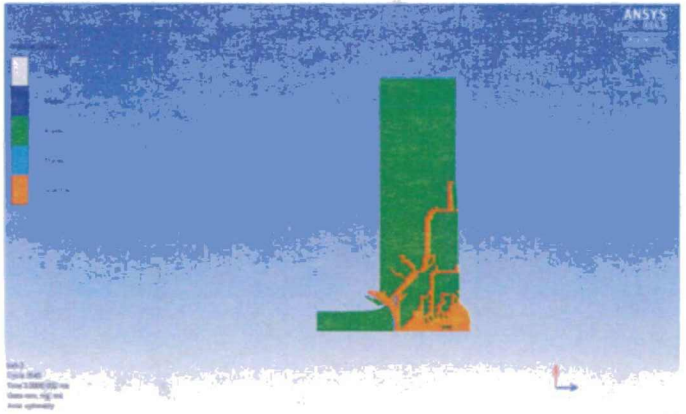


0.30-mm

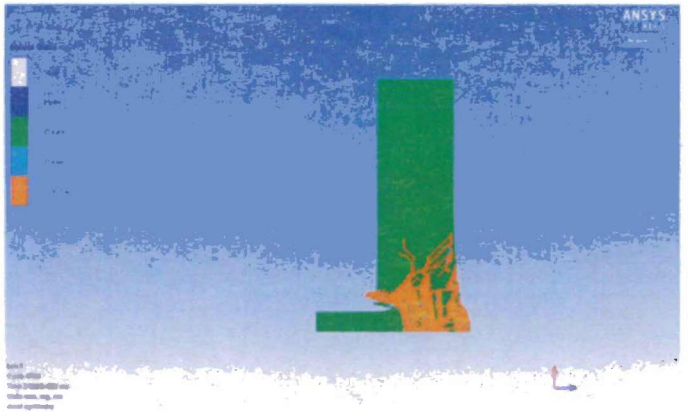


0.20-mm

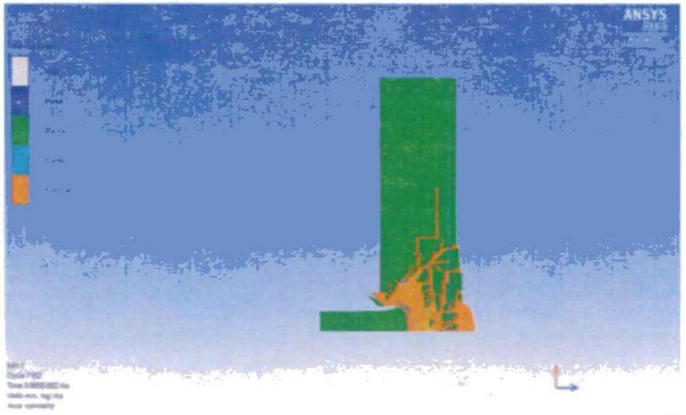
Fracture Patterns for All Mesh Sizes
t = 0.030-ms



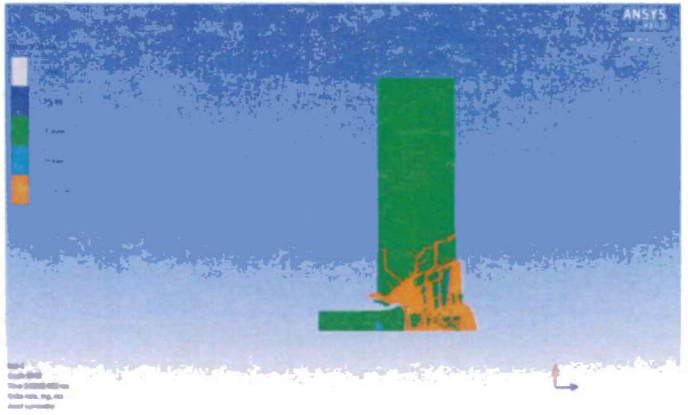
0.50-mm



0.40-mm

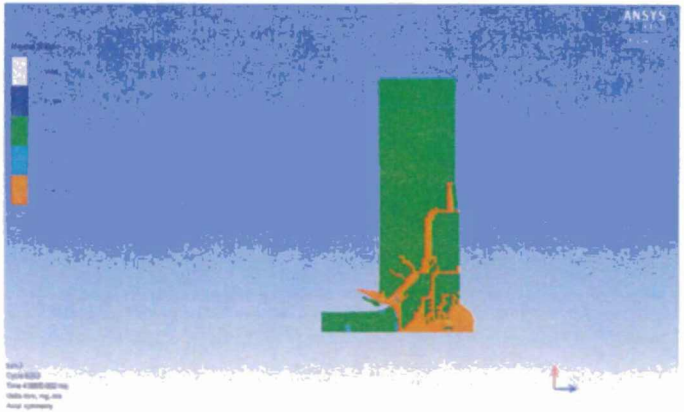


0.30-mm

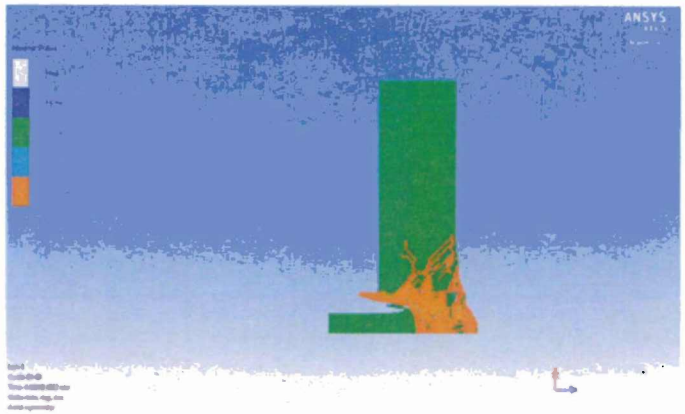


0.20-mm

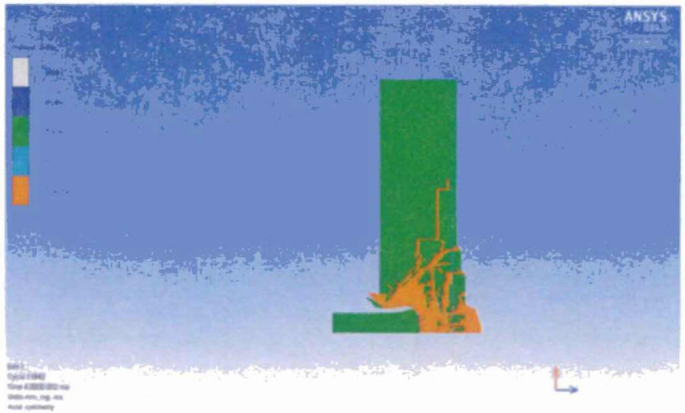
Fracture Patterns for All Mesh Sizes
t = 0.040-ms



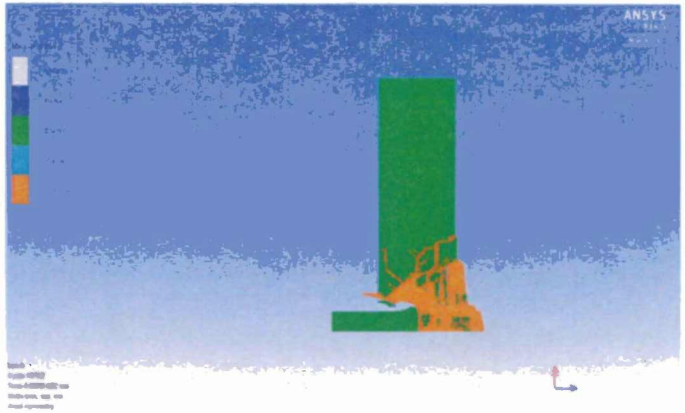
0.50-mm



0.40-mm



0.30-mm



0.20-mm

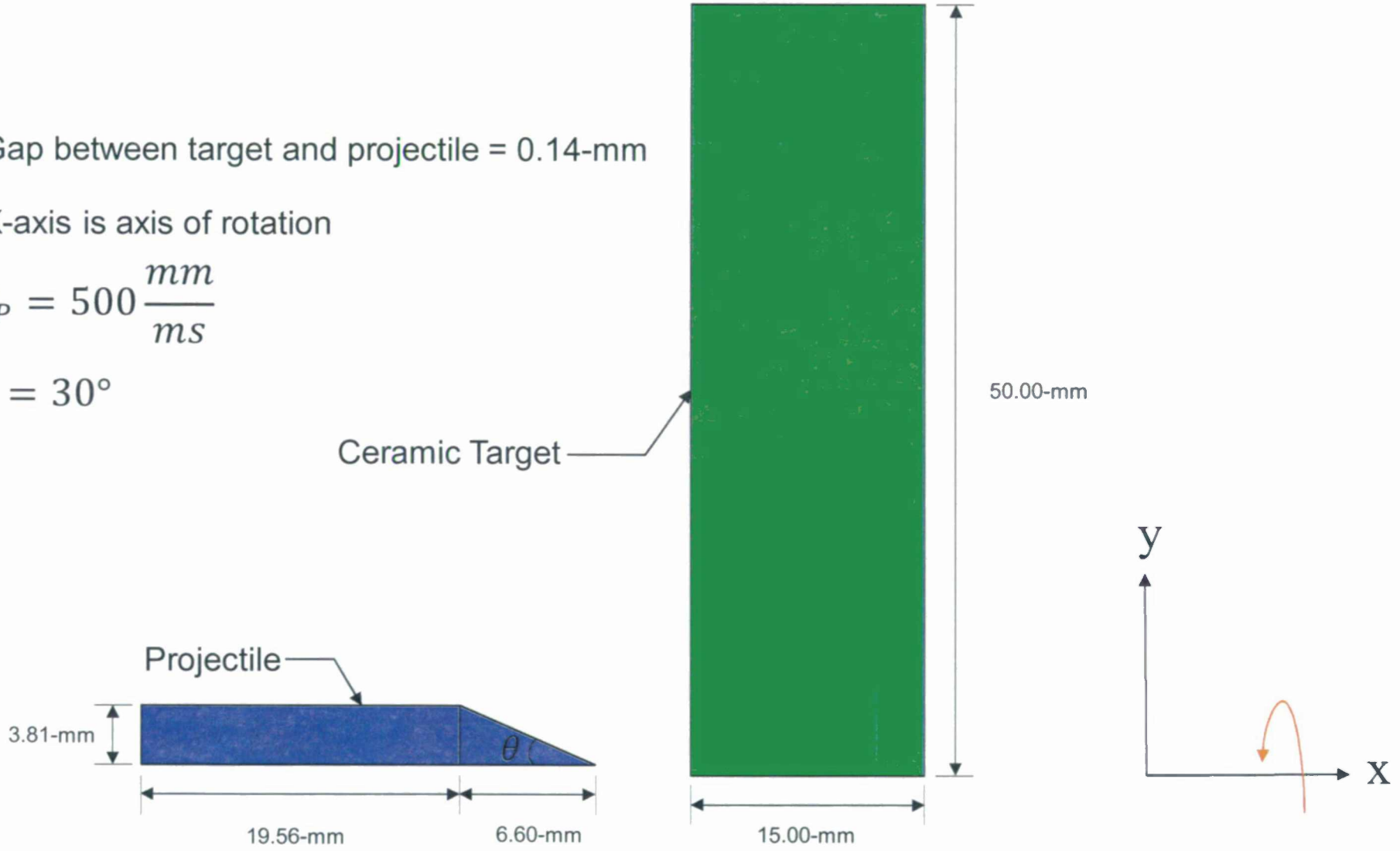
Axi-Symmetric Model Geometry

Gap between target and projectile = 0.14-mm

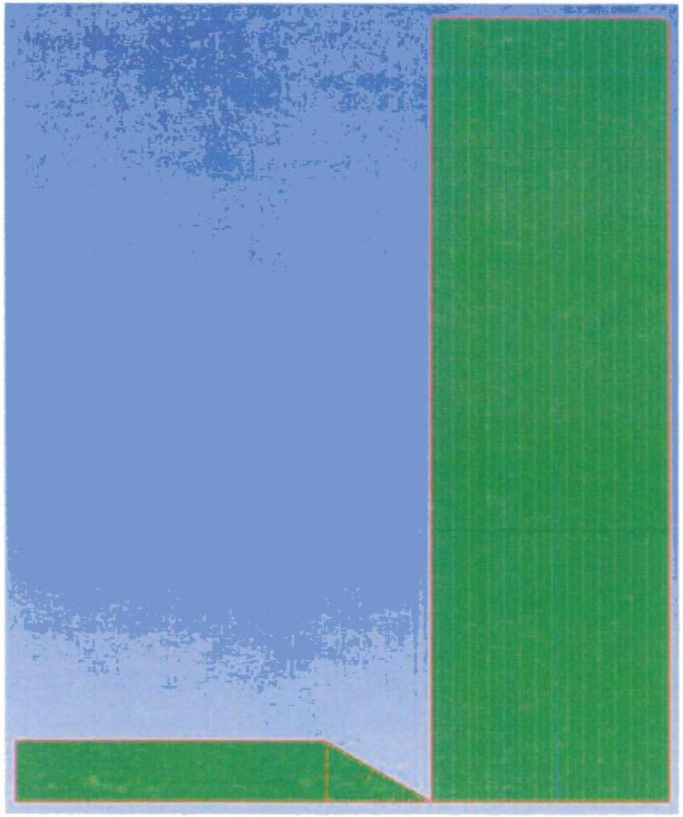
X-axis is axis of rotation

$$V_P = 500 \frac{mm}{ms}$$

$$\theta = 30°$$

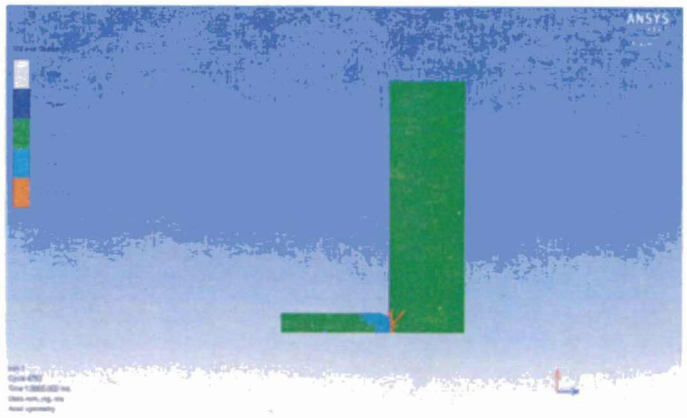


Mesh Size Investigated

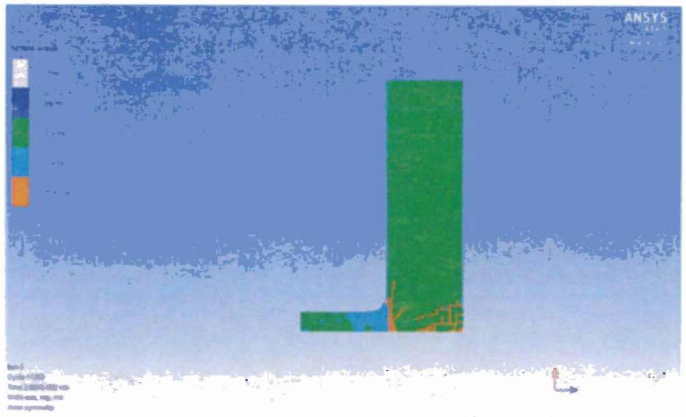


0.20-mm

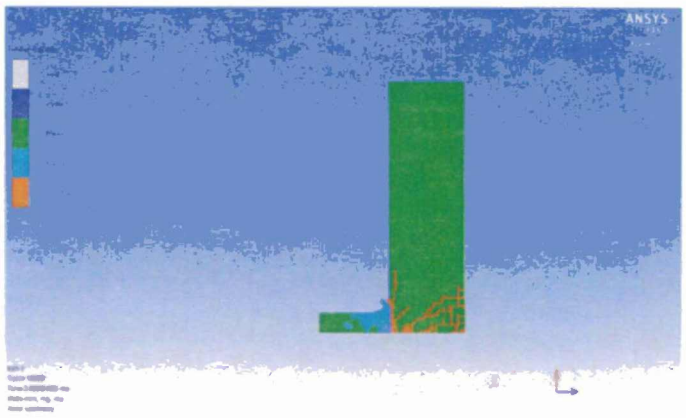
Fracture Pattern for 0.20-mm Mesh



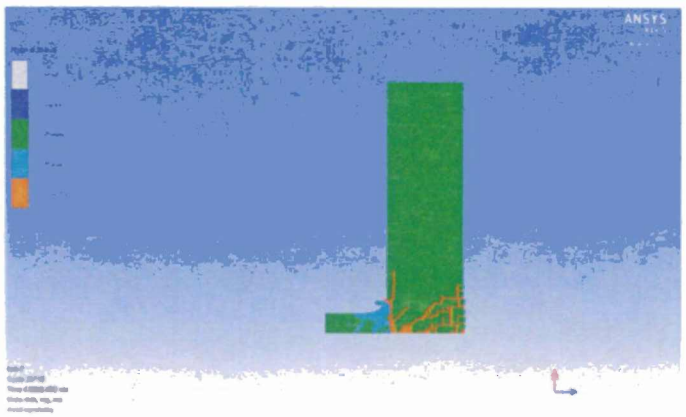
0.010-ms



0.020-ms



0.030-ms



0.040-ms